THE WEATHER AND CIRCULATION OF OCTOBER 1954 [1]

Including a Discussion of Hurricane Hazel in Relation to the Large-scale Circulation

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CIRCULATION AND TEMPERATURE OVER THE UNITED STATES

The mean circulation for October at 700 mb. (fig. 1), possessed little amplitude and small height anomalies over the United States and was associated with temperatures (Chart I-B) which were, for the most part, not far removed from normal. Extreme positive anomalies of 4° F. were observed both in southern Arizona (in connection with the +80-ft. height anomaly in that area) and in the Middle and North Atlantic States (a result of southerly anomalous flow and positive height departures). The lowest temperatures with respect to normal occurred in the northern part of the Great Basin in the center of a stronger-than-normal mean High at sea level (Chart XI).

The monthly anomalies were small because the monthly mean was an average of two dissimilar circulation patterns. The one which prevailed during the first half of the month was a continuation of the September pattern [1]. The other occurring in the latter half of the month represented a ridge-trough phase shift of about 180° in the area of the United States. During the first part of October (fig. 2) the westerlies were stronger than normal with a ridge present over the East, a weak trough in the Northern Plains States and another off the Pacific Coast. This pattern was associated with above normal temperatures over most of the country and below normal only in the north and west (fig. 3). Some of the daily maximum temperatures during this period were: Greensboro, N. C., 95°; Columbia, S. C., 101°; Raleigh, N. C., 98°; Augusta, Ga., 97°; Washington, D. C., 93°; and Boston, Mass., 90°. During the last half month (fig. 2) the westerlies weakened and a ridge was established along the Pacific Coast accompanied by a trough in the East with a change to below normal temperatures over most of the country (fig. 3).

CHANGES IN THE PLANETARY WAVE PATTERN AND THE MOTION OF HURRICANE HAZEL

The change in circulation occurred over a period of about a week near the middle of the month. During this week the eighth hurricane of the season, Hazel, lashed the island of Haiti, the Bahamas, and the eastern part of the United States and Canada. (See Chart X for track.) Details of the storm's destruction can be found in the news accounts and in [2], and will not be treated in this article. What is of interest here is the motion of the storm during its later stages as related to changes in the broad-scale circulation pattern. The importance of the hemispheric circulation on the motion of hurricanes has been pointed out by Klein and Winston [3, 4].

The hurricane was first observed as it crossed the Windward Islands early in the month when it was already an intense storm with winds of 100 m. p. h. During the following week it moved westward and continued to intensify as it passed about 100 miles north of the Venezuelan coast, after which it curved slowly northward and northeastward, reaching the island of Haiti by October 12. At this time the mid-latitude westerlies were strong, the wave-length long, and a ridge of high pressure was situated along the east coast of the United States. (See fig. 4 for this and following discussion.)

Furthermore, the polar front in the Pacific was oriented in a WSW-ENE direction with a marked thermal gradient across it (not shown). By October 13 a wave cyclone had formed near the Aleutians and the amplitude of the westerlies downstream began to increase. The cyclone continued to grow, acquiring on the 14th an intense circulation, while downstream heights continued to rise all along the Pacific coast and started to fall throughout the Central Plains. Hurricane Hazel meanwhile continued its northward motion curving toward the northwest as it was deflected by the strengthening ridge to its north. On the 15th the trough in the Plains States (and a surge of cold air with it) moved eastward accompanied by strong deepening over Lake Superior. Between this deepening trough and the stationary High off the Middle Atlantic coast the southerly flow intensified. Hazel under the influence of this steering current, was swept inland in the Carolinas and carried rapidly northward, acquiring not long afterwards the characteristics of an intense extratropical storm as the cold continental air to its west spiraled into its center. The hurricane center followed a track from the Carolinas, through Virginia, Maryland (passing through the western suburbs of Washington, D. C.), Pennsylvania, and New York into Canada, traversing this entire distance in some 12 hours. As it passed and the trough moved to the east coast, pronounced

[1] See Charts I–XV following p. 316 for analyzed climatological data for the month.

cooling took place throughout the East, while in the West a strong ridge established itself over the Basin accompanied by a warming trend.

A time-longitude section of daily 700-mb. height changes (fig. 5) is a convenient device for studying these changes. Here the diagonal line in the figure relates the initial deepening in the central Pacific with the subsequent changes downstream, and its slope is a measure of the group velocity [5], which was found to be 28 m. p. s. in this case. The process herein described resembles the typical index cycle where the westerlies and meridional thermal gradient strengthen together until some critical point is reached beyond which the westerlies become unstable. This instability is released in some portion of the hemisphere through rapid cyclogenesis, and an increase in amplitude of the westerlies is then propagated downstream.

PRECIPITATION IN THE UNITED STATES

Despite the presence of only weak negative height anomalies in the Great Lakes region on the monthly mean chart (fig. 1) precipitation in this area and just to its east was considerable (Chart III), occurring primarily during the first half of the month. Chicago, for example, received 12.06 inches and experienced 14 days of 0.01 inch or greater,[2] while Pittsburgh received 7.79 inches and had 15 days of measurable precipitation. This extensive

[2] See article by Nash and Chamberlain on Chicago storm of Oct. 9–11, in this issue.

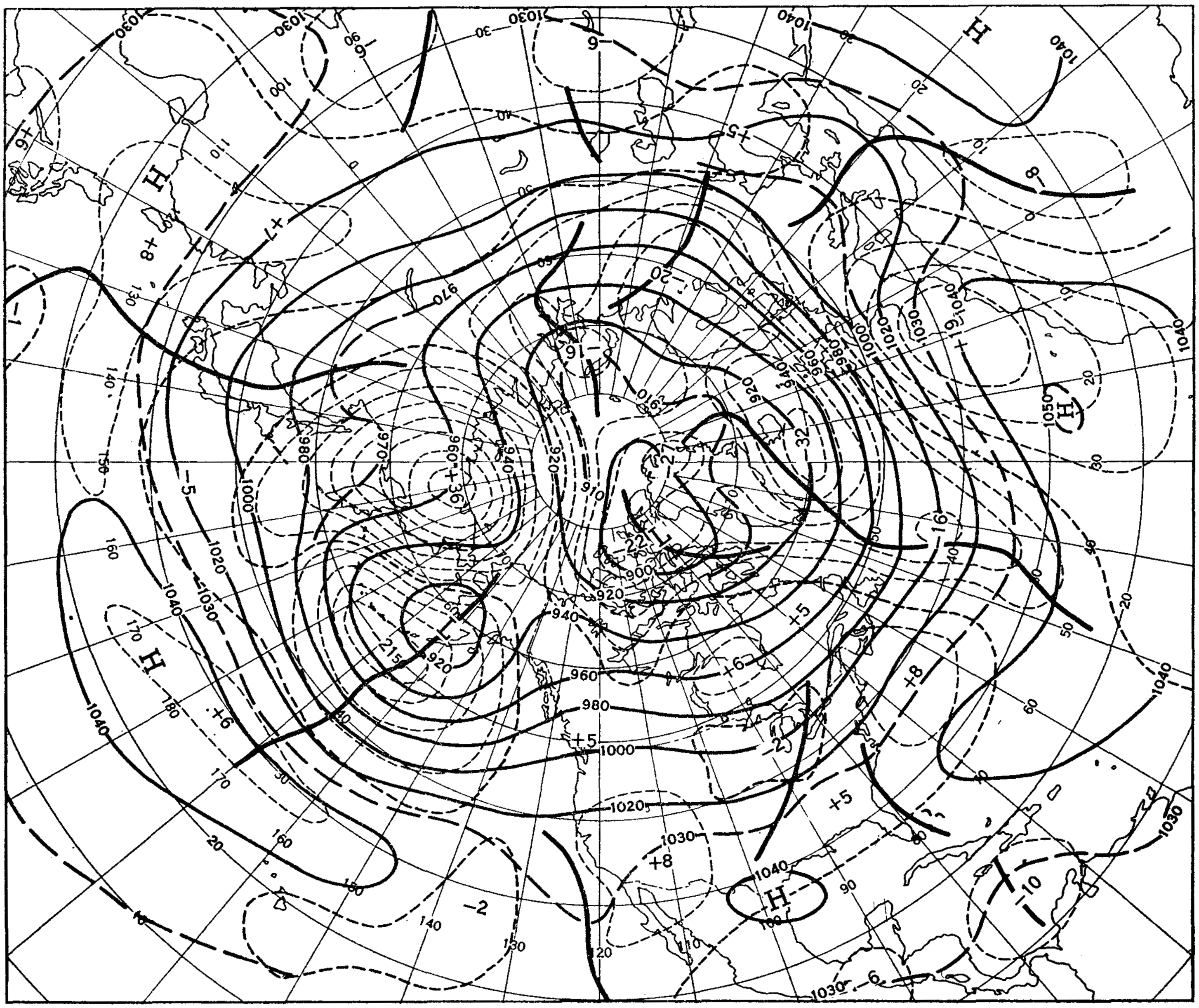


FIGURE 1.—Mean 700-mb. contours and height departures from normal (both in tens of feet) for October 2–31, 1954. Height anomalies were not far from normal over North America but quite large in the rest of the hemisphere.

precipitation was linked with the large number of days with fronts in the Central Plains and Lower Lakes region (fig. 6). During the first part of the month the fronts which pushed south across the Canadian border occasionally became quasi-stationary in the Lakes region, being unable to penetrate farther due to the strong high-level anticyclone in the Southeast. These fronts had pronounced thermal contrasts in the mid-troposphere and were associated with strong jets, but while overrunning and precipitation were frequently appreciable, wave formation was weak.

The large precipitation amounts in the Carolinas and Virginia were largely due to the hurricane, which provided the first soaking rains in months for much of these drought-stricken States. It gave Charleston, S. C., for example 88 percent of its monthly rainfall total, while Roanoke, Va., received some 73 percent of its total from the storm.

In Mississippi, northern Georgia, and western South Carolina, however, drought conditions continued as a consequence of the prevailing anticyclonic circulation at sea level (Chart XI) and westerly flow aloft. Fronts that travelled this far south usually were unattended by any wave formation. Insignificant precipitation amounts similarly occurred west of the Rockies in connection with the Basin High and above normal heights at 700 mb.

Most of the heavy rainfall in southeastern Texas was associated with a weak, tropical disturbance which moved inland from the Gulf of Mexico on October 5, and gave amounts as great as 6 inches in 6 hours in Brownsville. This disturbance weakened as it curved around the subtropical High cell into southeastern New Mexico, while at the same time cold air moved in from the northeast at lower levels and banked against the mountains. The resulting rainfall over the eastern slopes of the Rockies in New Mexico was copious and caused flash floods in the Pecos River and its tributaries.

CIRCULATION FEATURES IN OTHER PARTS OF THE HEMISPHERE

While the monthly 700-mb. height anomalies over North America were small, significant anomalies were

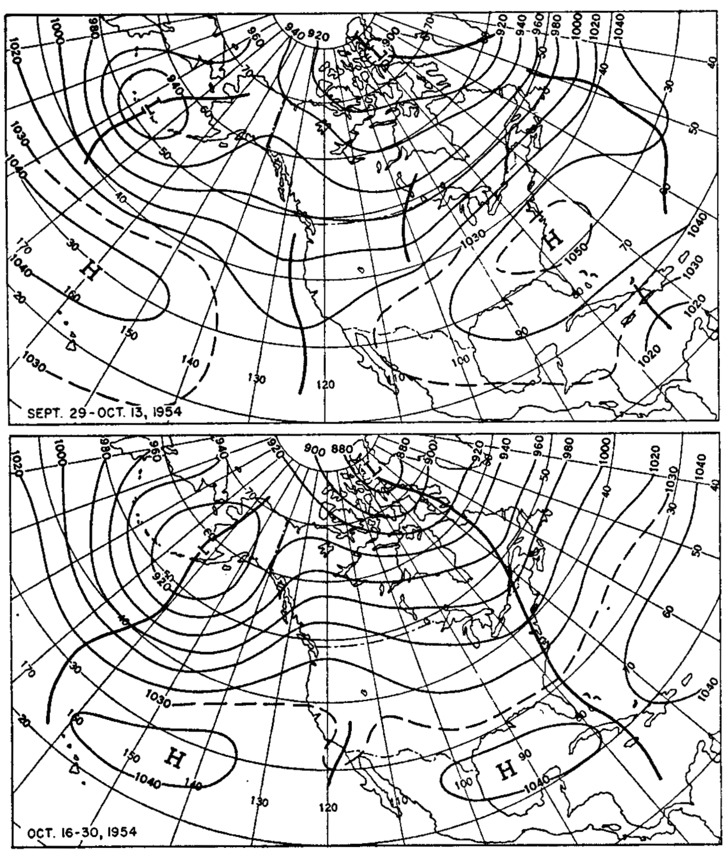


FIGURE 2.—Mean 700-mb. contours for 15-day periods September 29–October 13, 1954, and October 16–30, 1954. The strong high-level anticyclone in the Southeast early in the month gave way to a trough during the second half of the month with a change to much cooler weather as a consequence.

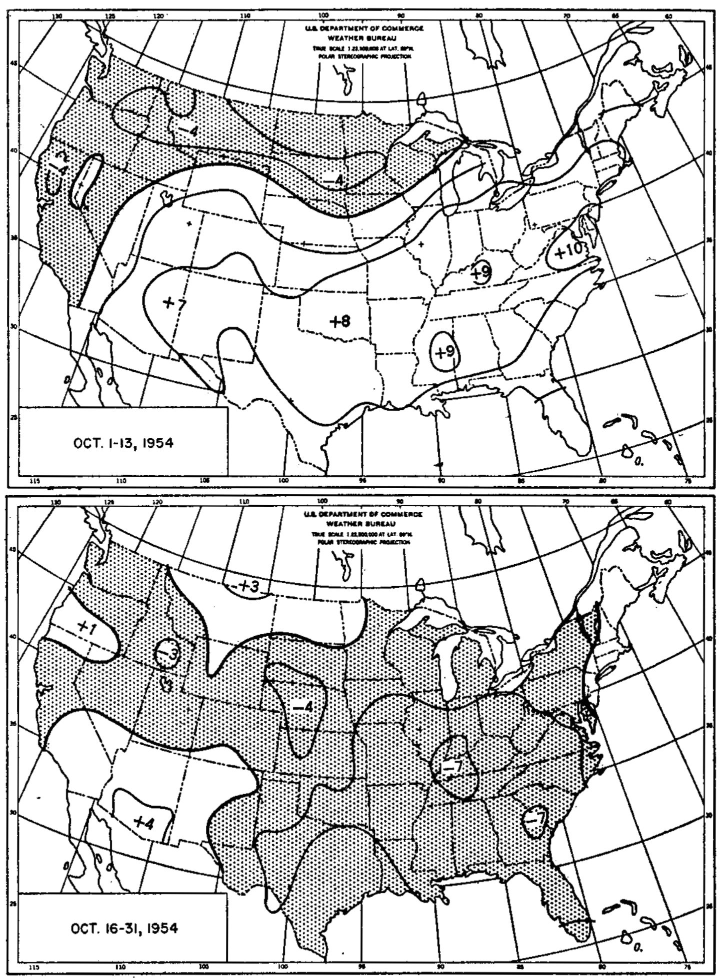


FIGURE 3.—Departures of average temperatures from normal for October 1–13, 1954, and October 16–31, 1954. Isopleths are drawn for intervals of 3° F. The change in temperature anomaly was as great as 16° between the two periods.

present over other parts of the hemisphere. The largest was that over northeastern Siberia where heights were 350 ft. above normal. This anomaly was established early in the month when a blocking ridge retrograded from Alaska and stabilized itself in the region. To its southeast the Aleutian Low and central Pacific trough were well developed with heights 200 ft. below normal. Strong northerly flow to the west transported considerable cold air into the central Pacific, bringing about a marked cooling from September and a strengthening of the north-south thermal gradient. Along this thermal contrast frequent cyclogenesis took place, with most of the storms moving into the Gulf of Alaska and then decaying.

In the central and northern Atlantic intense storminess was associated with a mean trough and heights depressed as much as 320 ft. from the normal. On the other hand the eastern Atlantic and southwestern Europe continued to experience above-normal heights as the Azores High

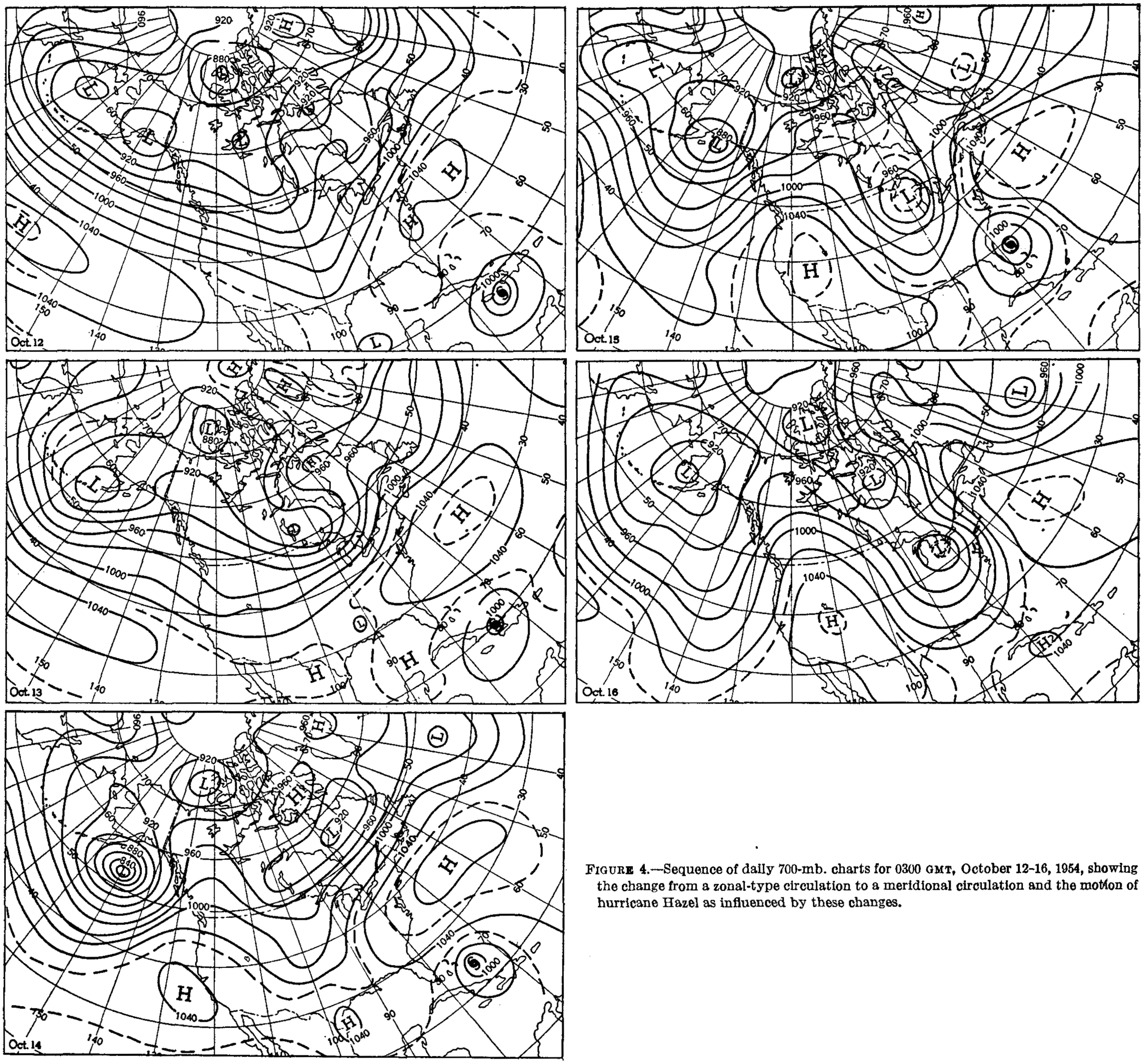


FIGURE 4.—Sequence of daily 700-mb. charts for 0300 GMT, October 12-16, 1954, showing the change from a zonal-type circulation to a meridional circulation and the motion of hurricane Hazel as influenced by these changes.

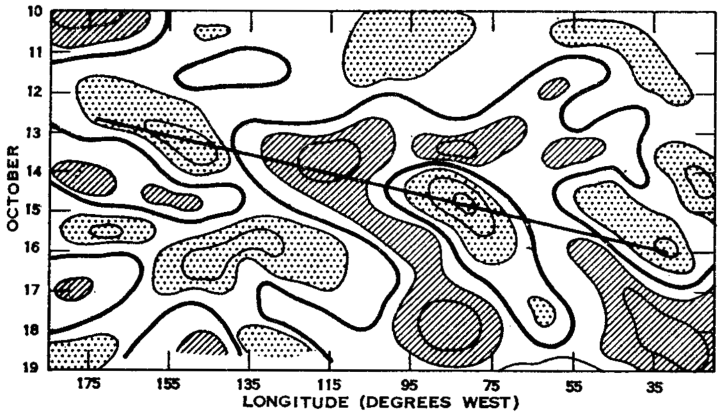


FIGURE 5.—Time-longitude section showing 24-hour height changes at 700 mb. for 45° N. Isopleths are drawn for every 200 feet of change with line of zero change heavier. Regions of height falls are stippled while those having rises are shaded. Diagonal line relates initial deepening with changes downstream. Falls took place on the 12th at 155° W. followed by rises on the 13th at 110° W. and falls on the 14th at 80° W.

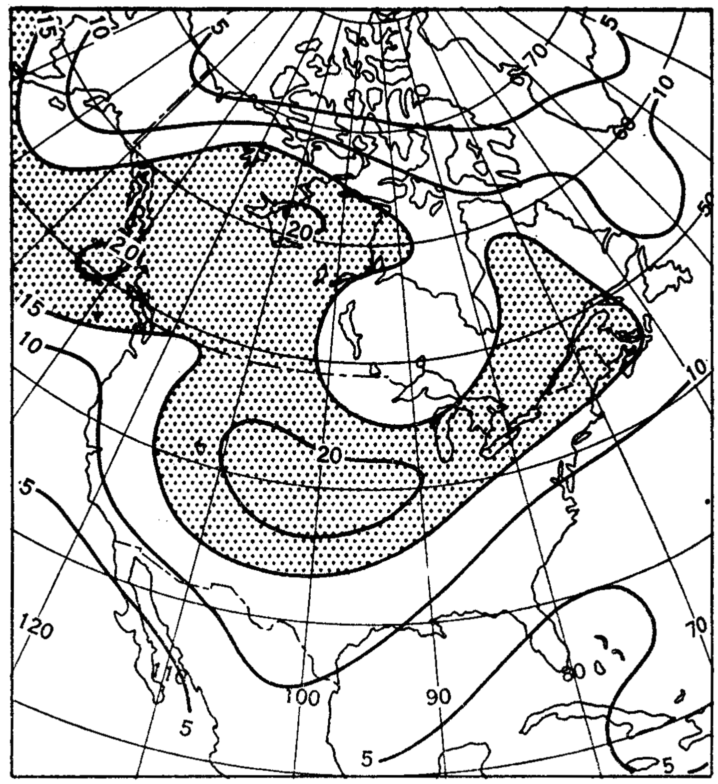


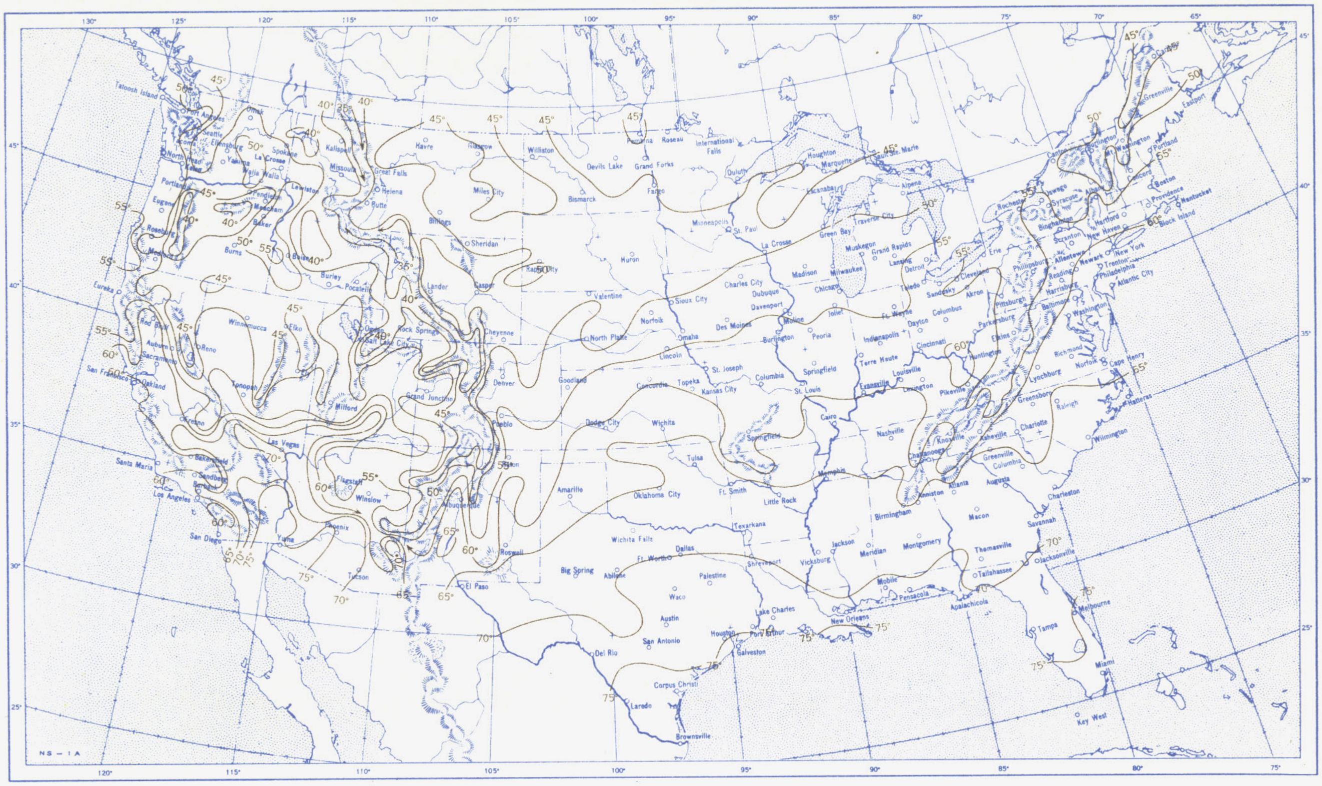
FIGURE 6.—Number of days in October 1954 with surface fronts of any type (within squares with sides approximately 500 miles). Frontal positions taken from *Daily Weather Map*, 1:30 p. m. EST. Note pronounced belt of frequent occurrence of fronts extending from the Lower Lakes to the Central Plains.

thrust itself strongly against the European and African coasts. This was accompanied by a deterioration of the weather over the Mediterranean as a trough became established in the central part. Although negative height anomalies associated with this trough were small, anomalous northerly flow into the western Mediterranean was strong, leading to considerable influx of polar maritime air into the region. As this cold air flowed in, closed cyclonic vortices frequently formed. These tended to persist for several days without appreciable motion and were accompanied by intense shower activity, particularly in the Salerno area of southern Italy where an all-time record of 20 inches of rain fell in 15 hours. These heavy rains led to floods and landslides in southern Italy on October 26 with considerable loss of life and property damage.

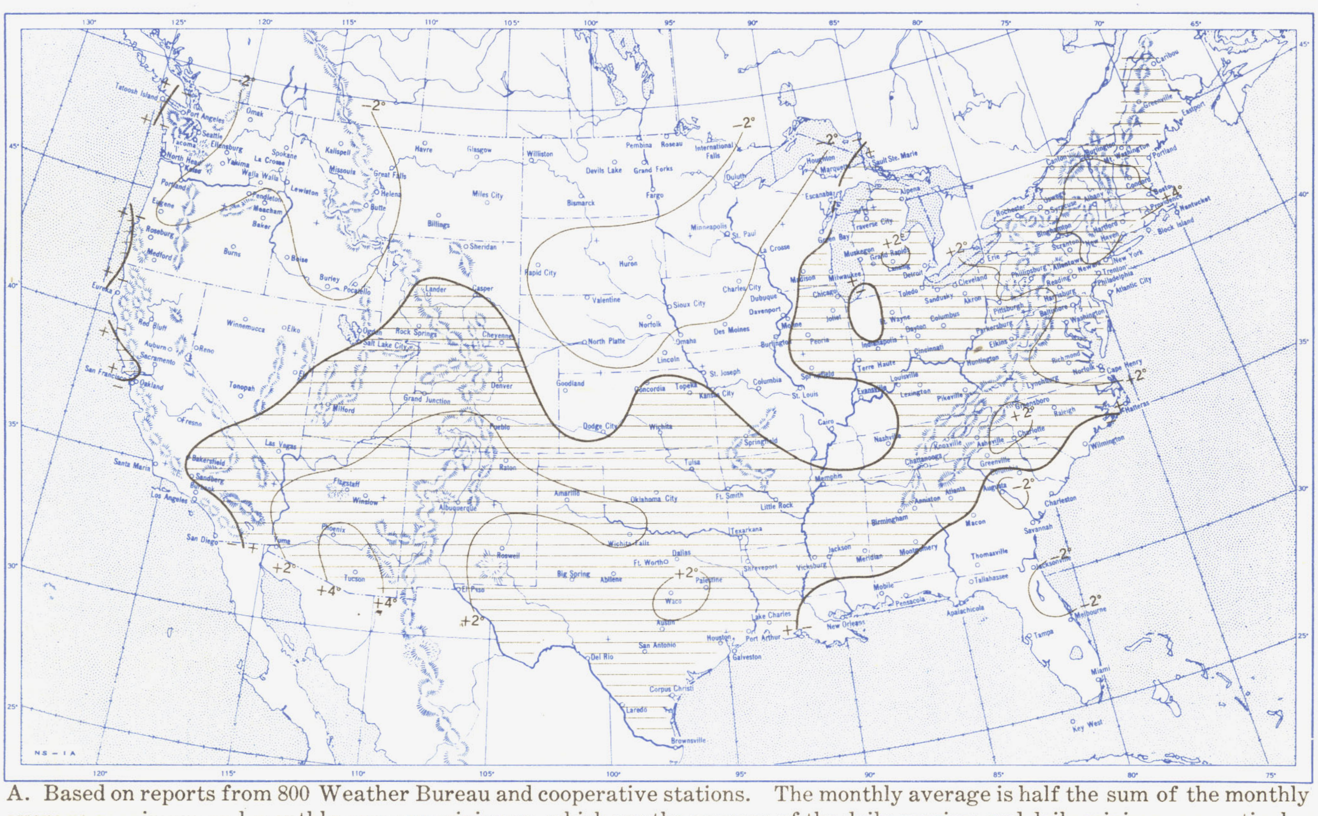
REFERENCES

1. J. S. Winston, "The Weather and Circulation of September 1954," *Monthly Weather Review*, vol. 82, No. 9, September 1954, pp. 261–266.
2. L. H. Seamon, "Hurricane Hazel," *Climatological Data, National Summary*, vol. 5, No. 10, October 1954 (to be published).
3. W. H. Klein and J. S. Winston, "The Path of the Atlantic Hurricane of September 1947 in Relation to the Hemispheric Circulation," *Bulletin of the American Meteorological Society*, vol. 28, No. 7, Dec. 1947, pp. 447–452.
4. J. S. Winston, "The Weather and Circulation of August 1954—Including a Discussion of Hurricane Carol in Relation to the Planetary Wave Pattern," *Monthly Weather Review*, vol. 82, No. 8, Aug. 1954, pp. 228–235.
5. T. C. Yeh, "On Energy Dispersion in the Atmosphere," *Journal of Meteorology*, vol. 16, No. 1, Feb. 1949, pp. 1–16.

Chart I. A. Average Temperature (°F.) at Surface, October 1954.



B. Departure of Average Temperature from Normal (°F.), October 1954.

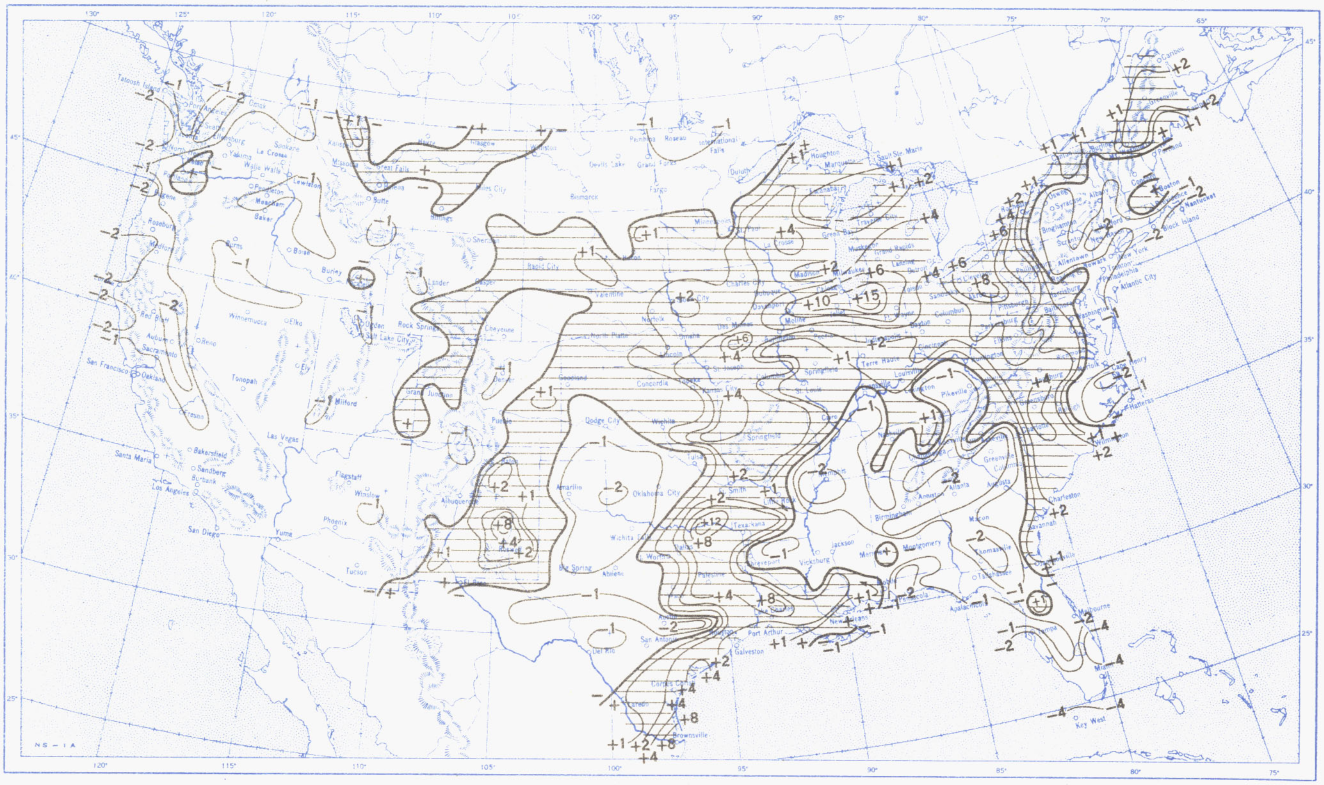


A. Based on reports from 800 Weather Bureau and cooperative stations. The monthly average is half the sum of the monthly average maximum and monthly average minimum, which are the average of the daily maxima and daily minima, respectively. B. Normal average monthly temperatures are computed for Weather Bureau stations having at least 10 years of record.

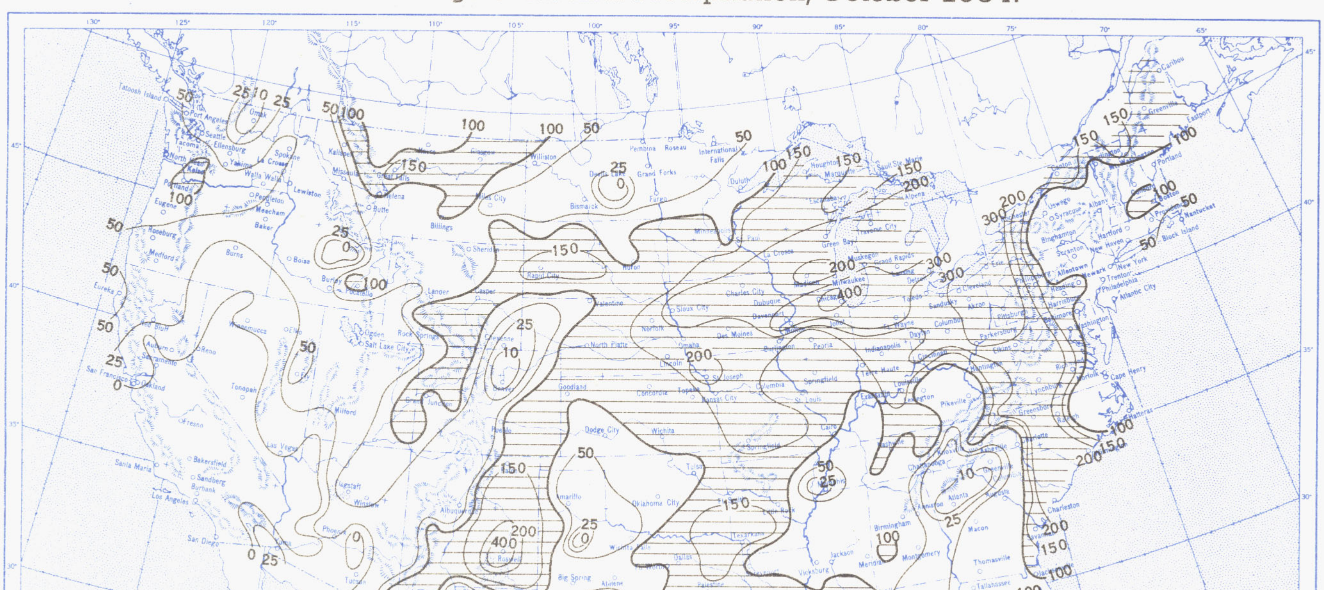
Chart II. Total Precipitation (Inches), October 1954.

Based on daily precipitation records at 800 Weather Bureau and cooperative stations.

Chart III. A. Departure of Precipitation from Normal (Inches), October 1954.

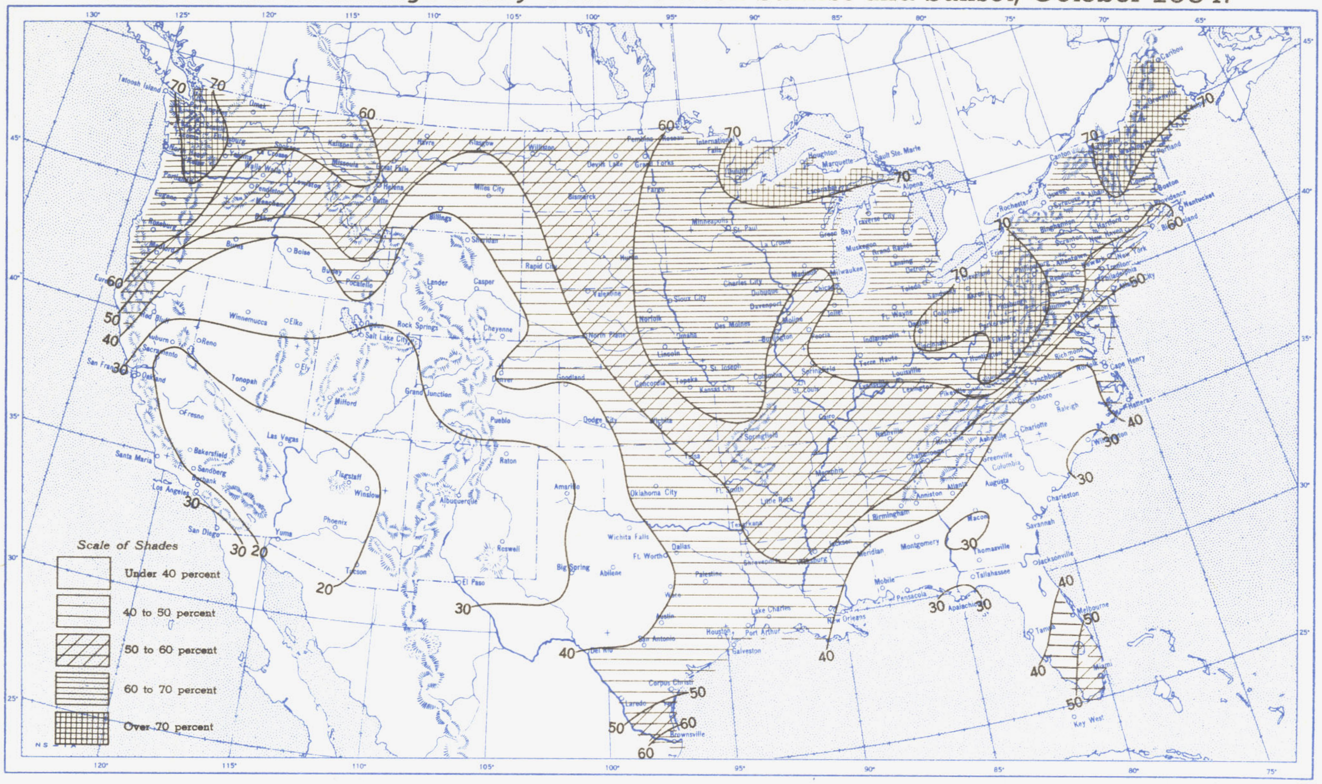


B. Percentage of Normal Precipitation, October 1954.

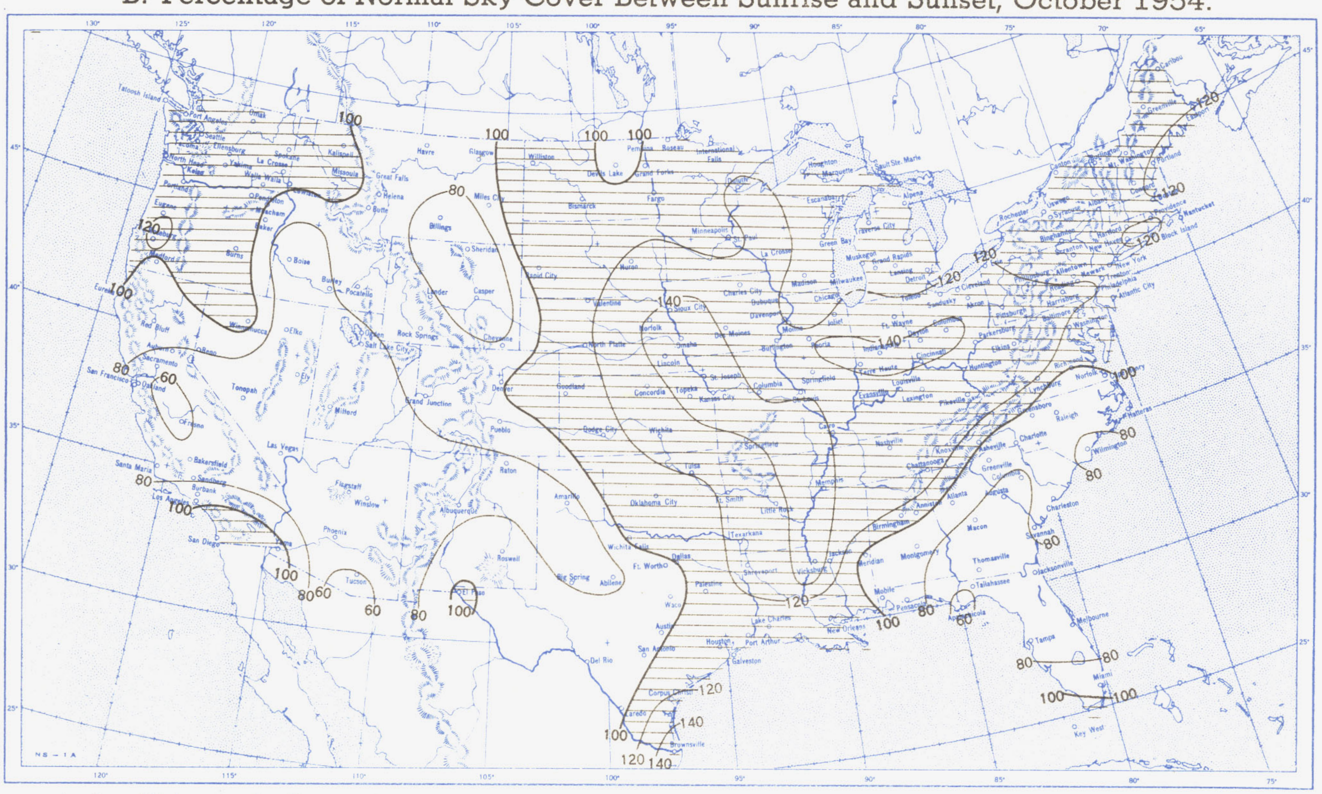


Normal monthly precipitation amounts are computed for stations having at least 10 years of record.

Chart VI. A. Percentage of Sky Cover Between Sunrise and Sunset, October 1954.

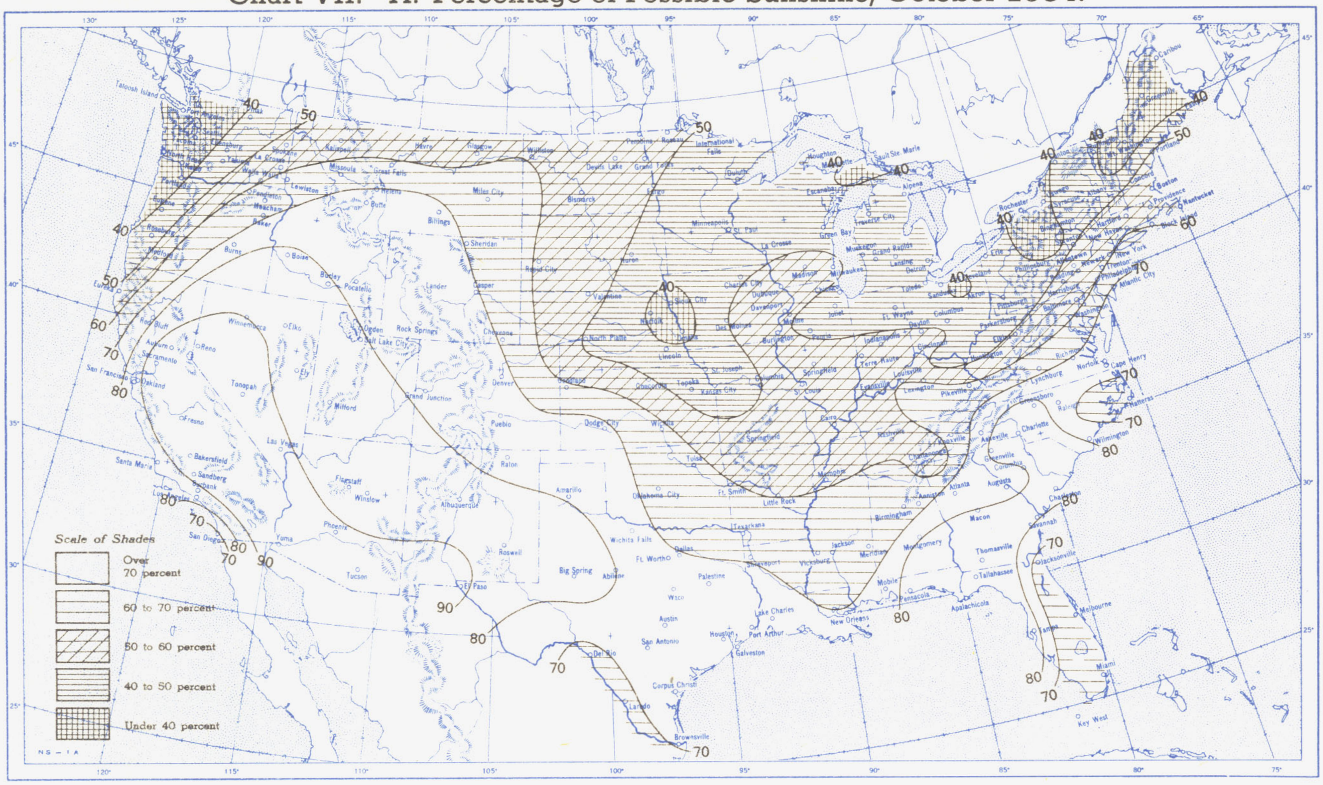


B. Percentage of Normal Sky Cover Between Sunrise and Sunset, October 1954.

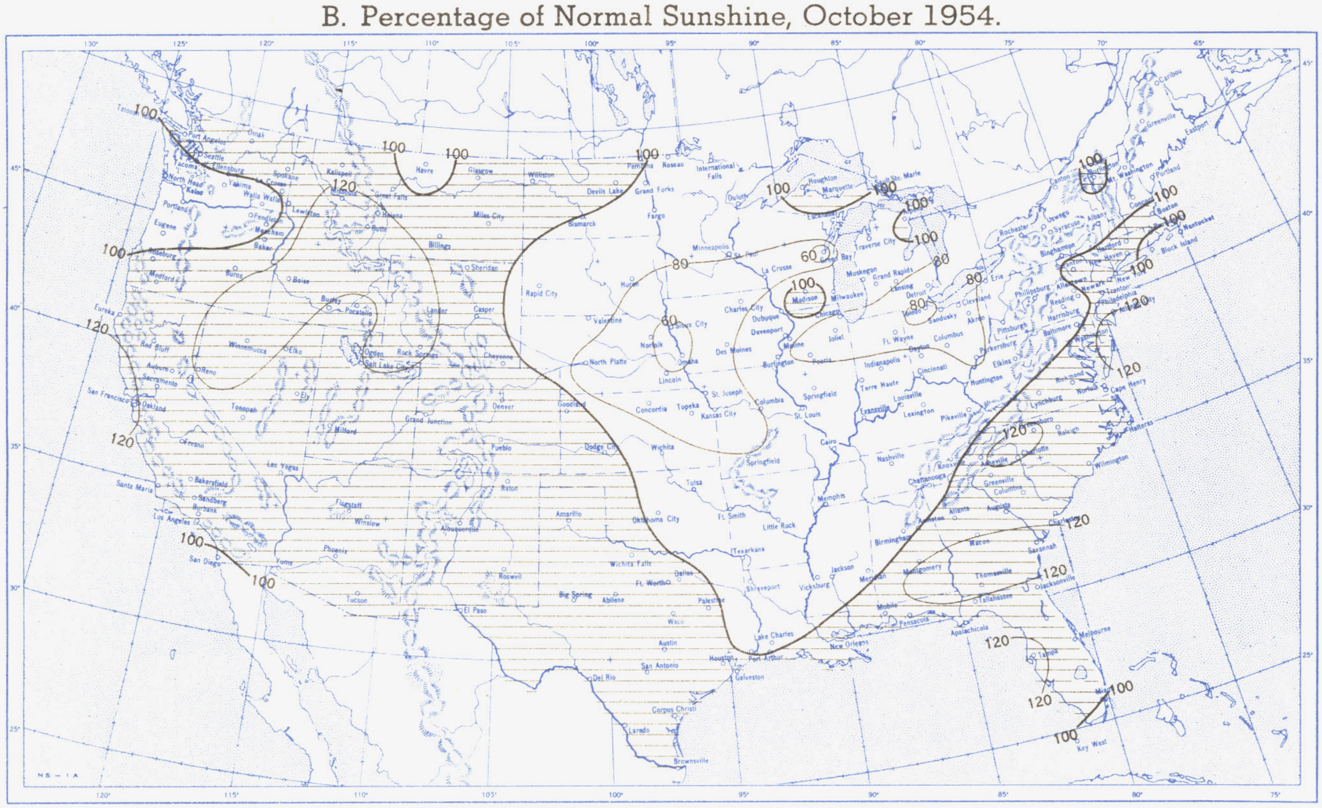


A. In addition to cloudiness, sky cover includes obscuration of the sky by fog, smoke, snow, etc. Chart based on visual observations made hourly at Weather Bureau stations and averaged over the month. B. Computations of normal amount of sky cover are made for stations having at least 10 years of record.

Chart VII. A. Percentage of Possible Sunshine, October 1954.



B. Percentage of Normal Sunshine, October 1954.



A. Computed from total number of hours of observed sunshine in relation to total number of possible hours of sunshine during month. B. Normals are computed for stations having at least 10 years of record.

Chart VIII. Average Daily Values of Solar Radiation, Direct + Diffuse, October 1954. Inset: Percentage of Normal Average Daily Solar Radiation, October 1954.

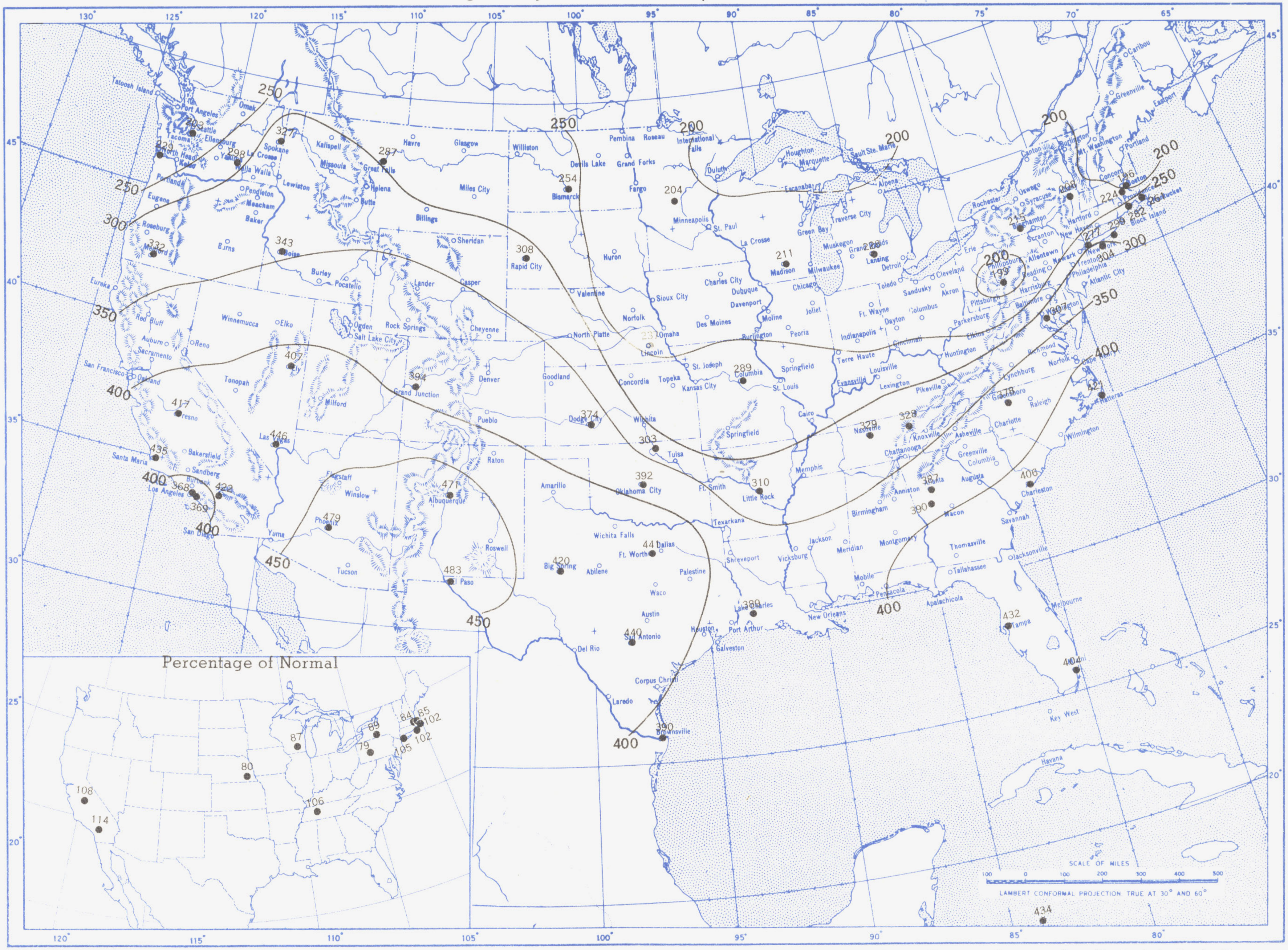
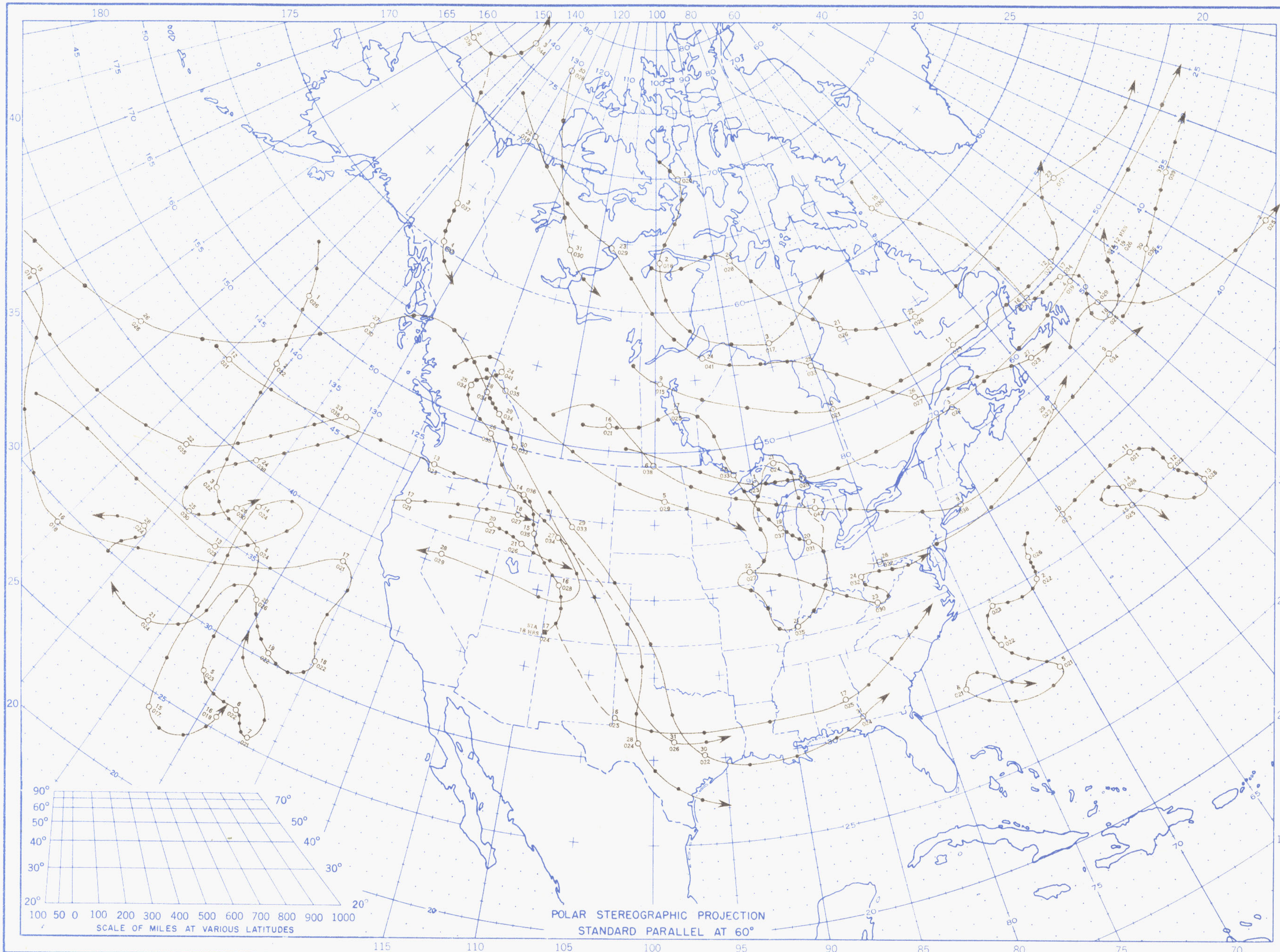


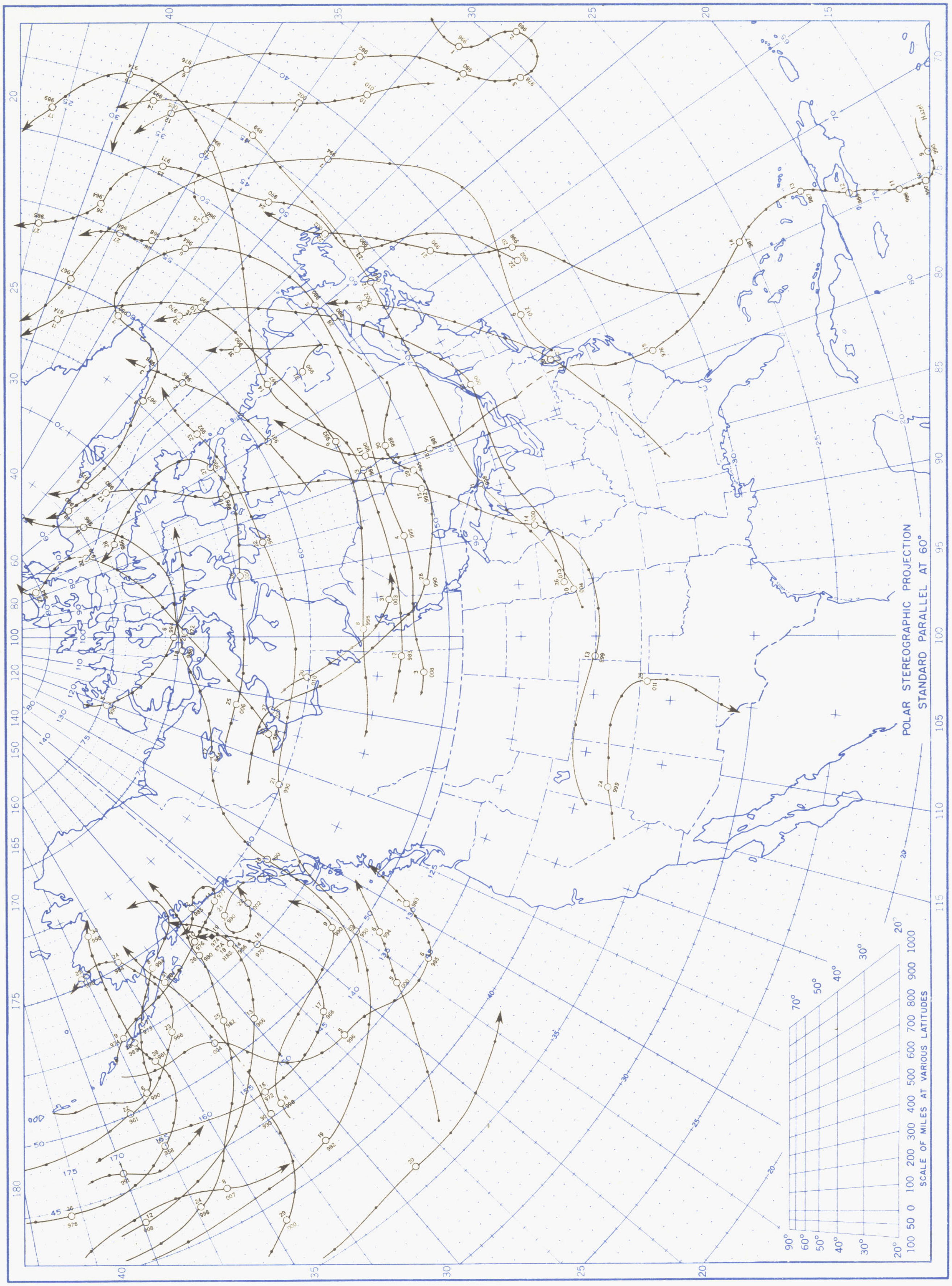
Chart shows mean daily solar radiation, direct + diffuse, received on a horizontal surface in langleys (1 langley = 1 gm. cal. cm.$^{-2}$). Basic data for isolines are shown on chart. Further estimates are obtained from supplementary data for which limits of accuracy are wider than for those data shown. Normals are computed for stations having at least 9 years of record.

Chart IX. Tracks of Centers of Anticyclones at Sea Level, October 1954.



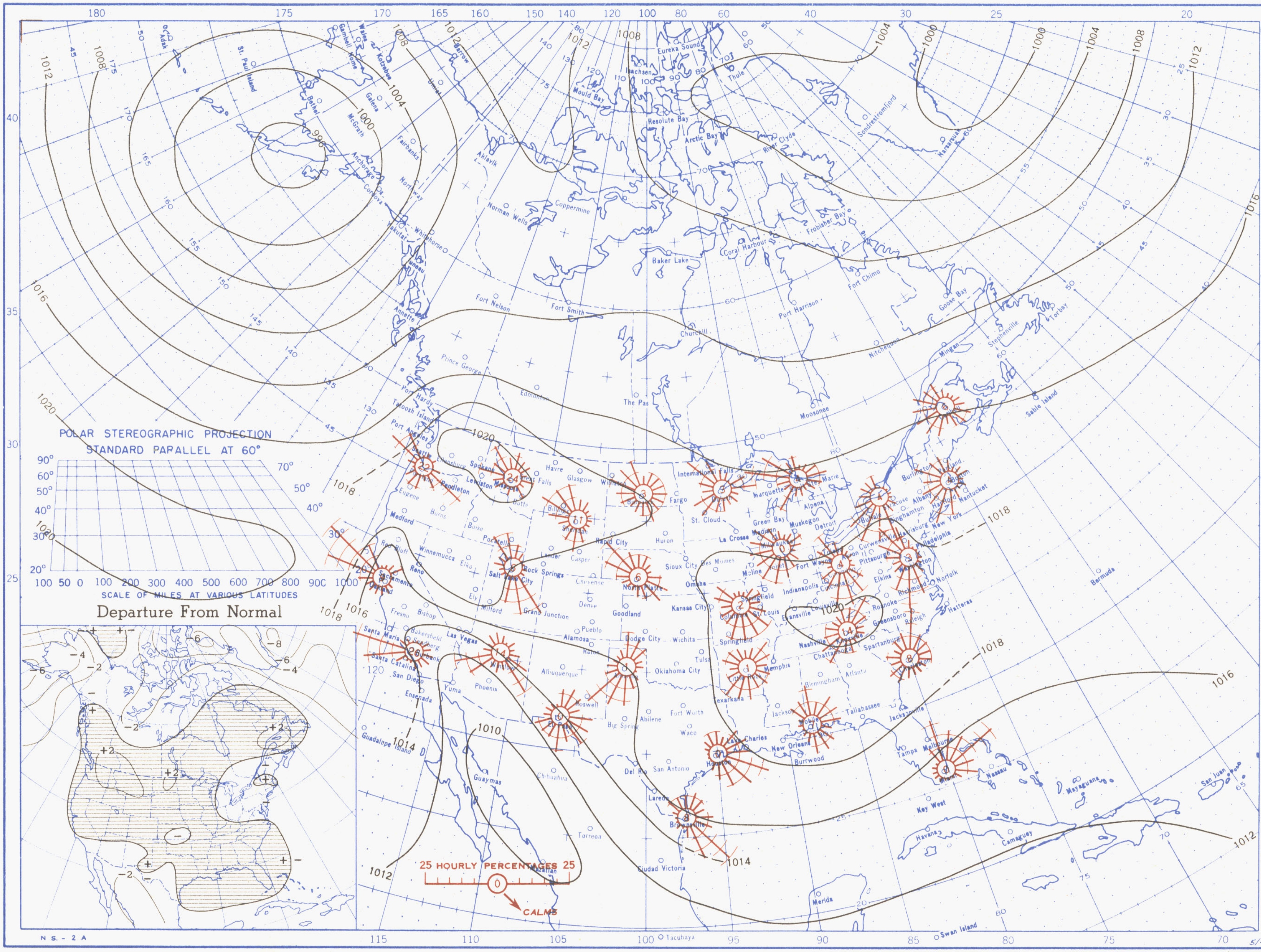
Circle indicates position of center at 7:30 a. m. E. S. T. Figure above circle indicates date, figure below, pressure to nearest millibar. Dots indicate intervening 6-hourly positions. Squares indicate position of stationary center for period shown. Dashed line in track indicates reformation at new position. Only those centers which could be identified for 24 hours or more are included.

Chart X. Tracks of Centers of Cyclones at Sea Level, October 1954.



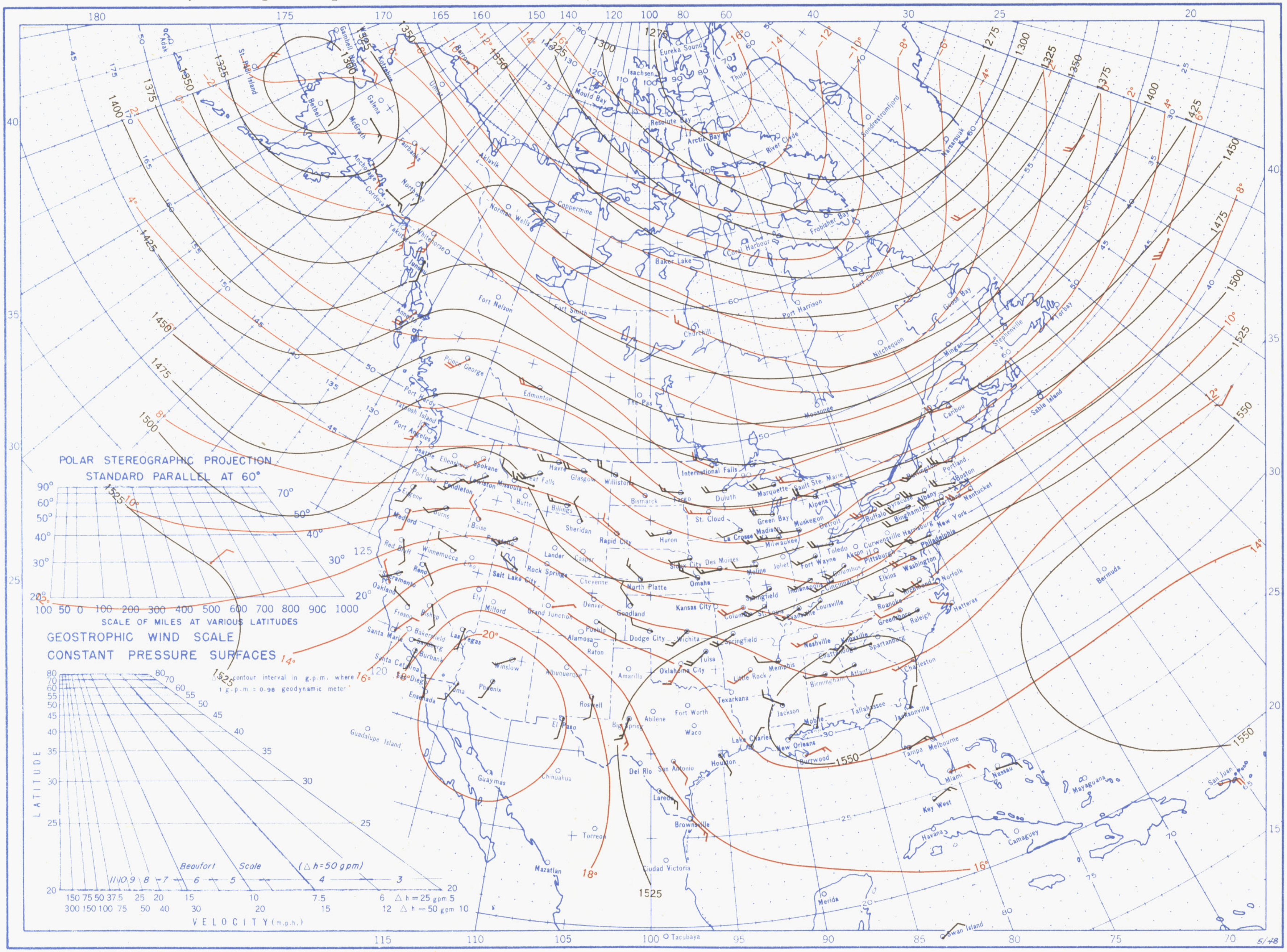
Circle indicates position of center at 7:30 a. m. E. S. T. See Chart IX for explanation of symbols.

Chart XI. Average Sea Level Pressure (mb.) and Surface Windroses, October 1954. Inset: Departure of Average Pressure (mb.) from Normal, October 1954.



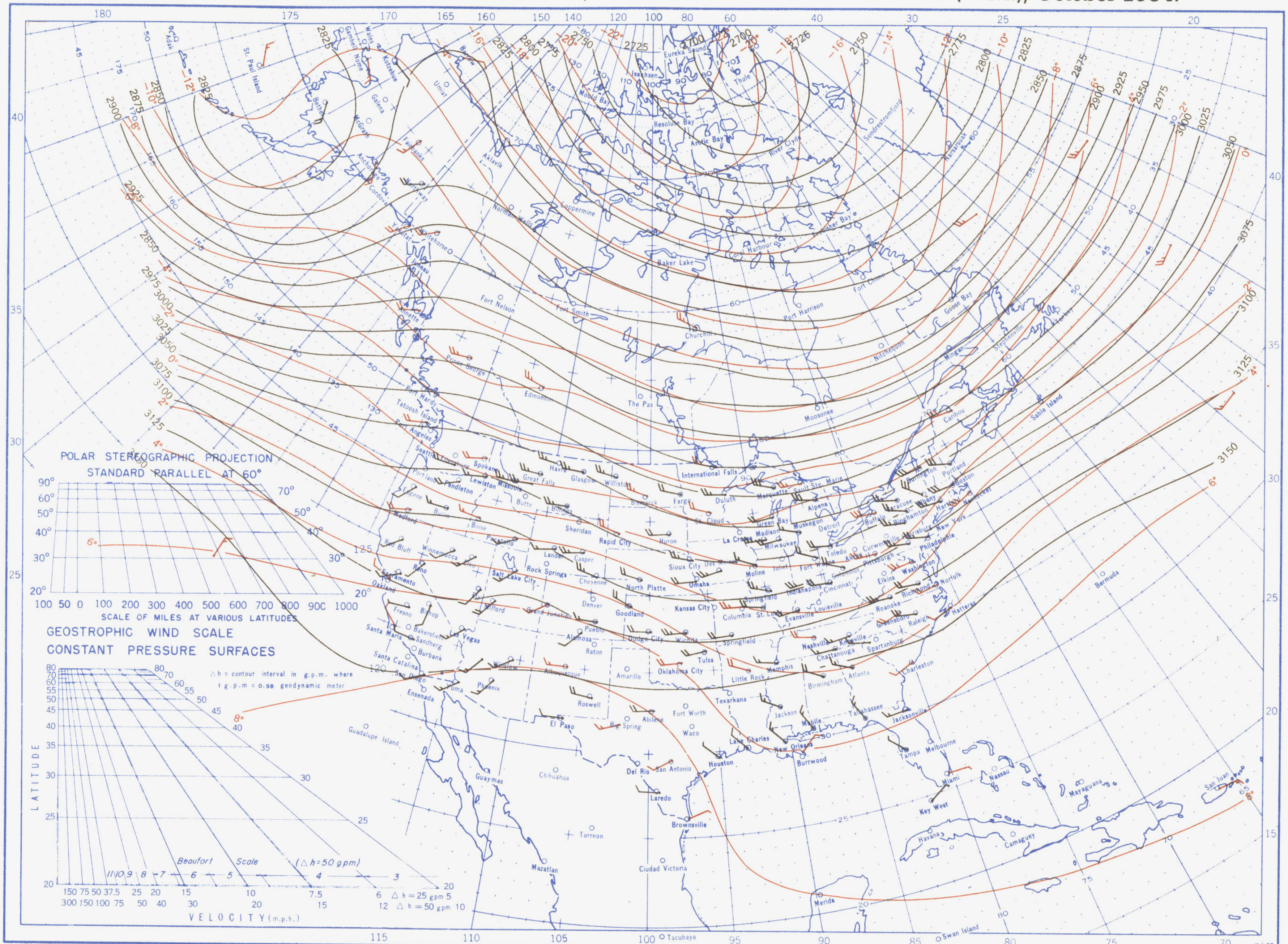
Average sea level pressures are obtained from the averages of the 7:30 a.m. and 7:30 p.m. E.S.T. readings. Windroses show percentage of time wind blew from 16 compass points or was calm during the month. Pressure normals are computed for stations having at least 10 years of record and for 10° intersections in a diamond grid based on readings from the Historical Weather Maps (1899-1939) for the 20 years of most complete data coverage prior to 1940.

Chart XII. Average Dynamic Height in Geopotential Meters (1 g.p.m. = 0.98 dynamic meters) of the 850-mb. Pressure Surface, Average Temperature in °C. at 850 mb., and Resultant Winds at 1500 Meters (m.s.l.), October 1954.



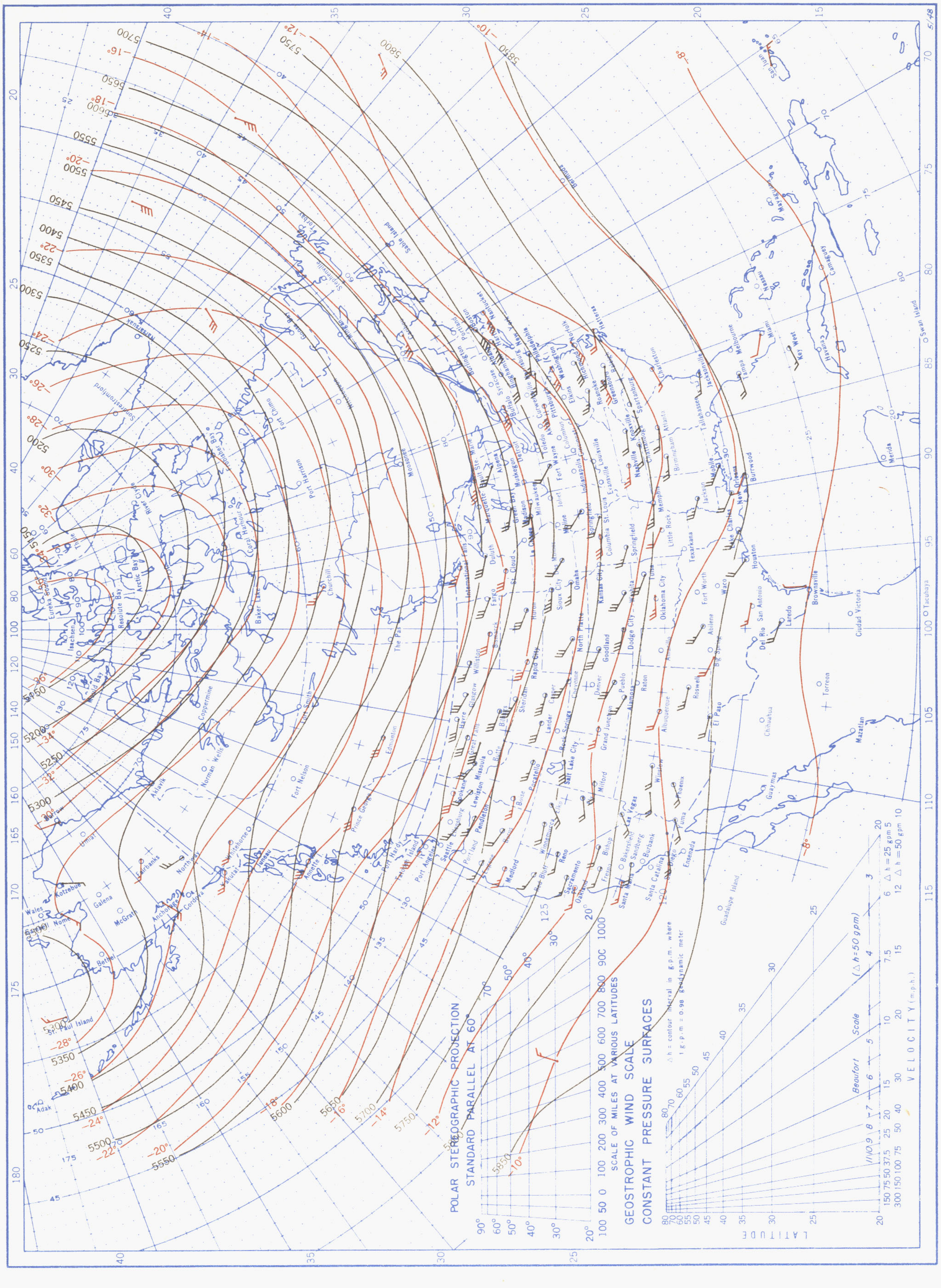
Contour lines and isotherms based on radiosonde observations at 0300 G. M. T. Winds shown in black are based on pilot balloon observations at 2100 G. M. T.; those shown in red are based on rawins at 0300 G. M. T. Wind barbs indicate wind speed on the Beaufort scale.

Chart XIII. Average Dynamic Height in Geopotential Meters (1 g.p.m.. = 0.98 dynamic meters) of the 700-mb. Pressure Surface, Average Temperature in °C. at 700 mb., and Resultant Winds at 3000 Meters (m.s.l.), October 1954.



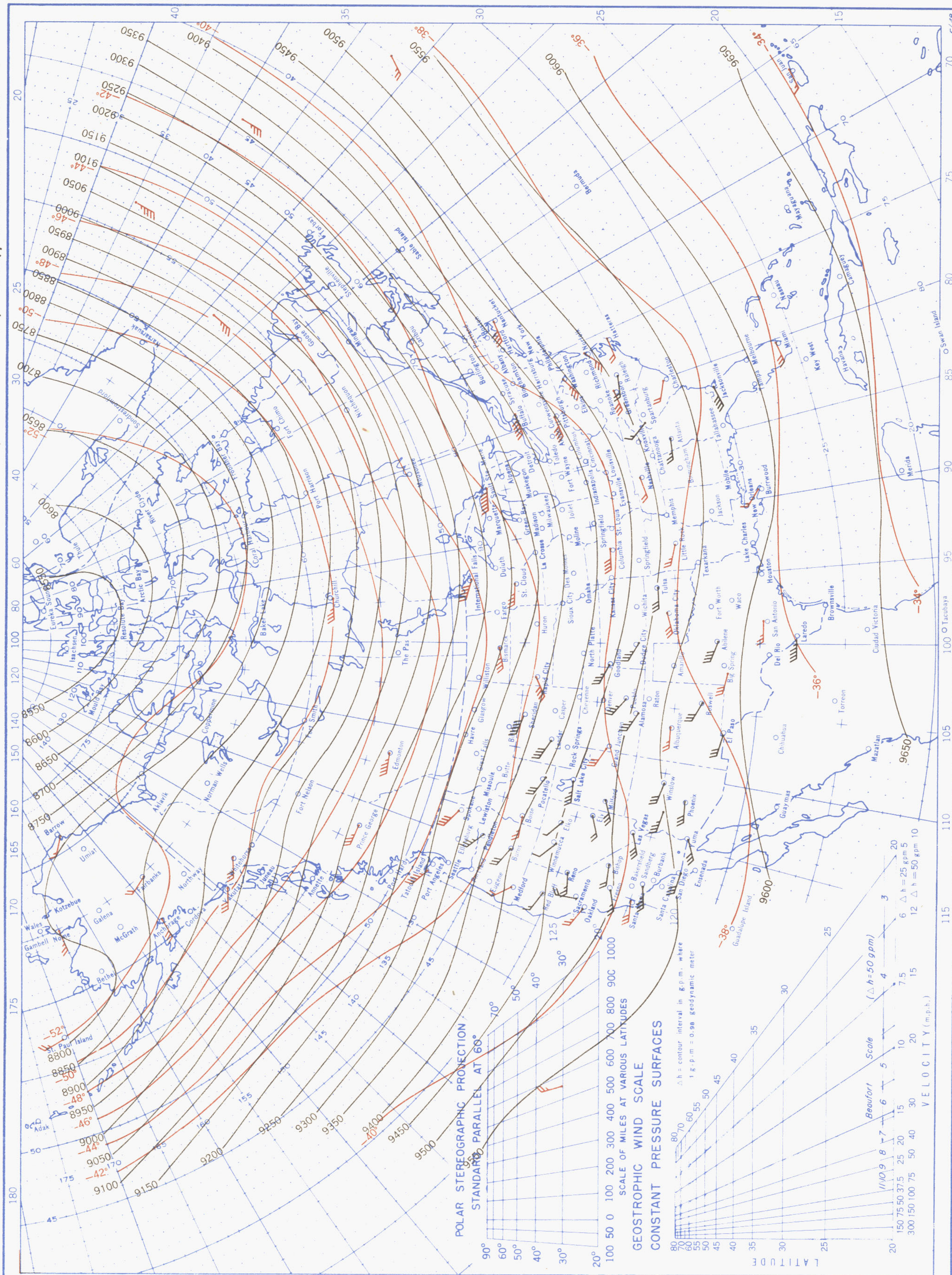
Contour lines and isotherms based on radiosonde observations at 0300 G. M. T. Winds shown in black are based on pilot balloon observations at 2100 G. M. T.; those shown in red are based on rawins at 0300 G. M. T. Wind barbs indicate wind speed on the Beaufort scale.

Chart XIV. Average Dynamic Height in Geopotential Meters (1 g.p.m. = 0.98 dynamic meters) of the 500-mb. Pressure Surface, Average Temperature in °C. at 500 mb., and Resultant Winds at 5000 Meters (m.s.l.), October 1954.



Contour lines and isotherms based on radiosonde observations at 0300 G. M. T. Winds shown in black are based on pilot balloon observations at 2100 G. M. T.; those shown in red are based on rawins taken at 0300 G. M. T. Wind barbs indicate wind speed on the Beaufort scale.

Chart XV. Average Dynamic Height in Geopotential Meters (1 g.p.m. = 0.98 dynamic meters) of the 300-mb. Pressure Surface, Average Temperature in °C. at 300 mb., and Resultant Winds at 10,000 Meters (m.s.l.), October 1954.



Contour lines and isotherms based on radiosonde observations at 0300 G. M. T. Winds shown in black are based on pilot balloon observations at 2100 G. M. T.; those shown in red are based on rawins taken at 0300 G. M. T. Wind barbs indicate wind speed on the Beaufort scale.